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**Lee et al.**

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(54) **FLUID STERILIZER AND ASSOCIATED CONNECTING DEVICE**

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See application file for complete search history.

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*Primary Examiner* — David E Smith

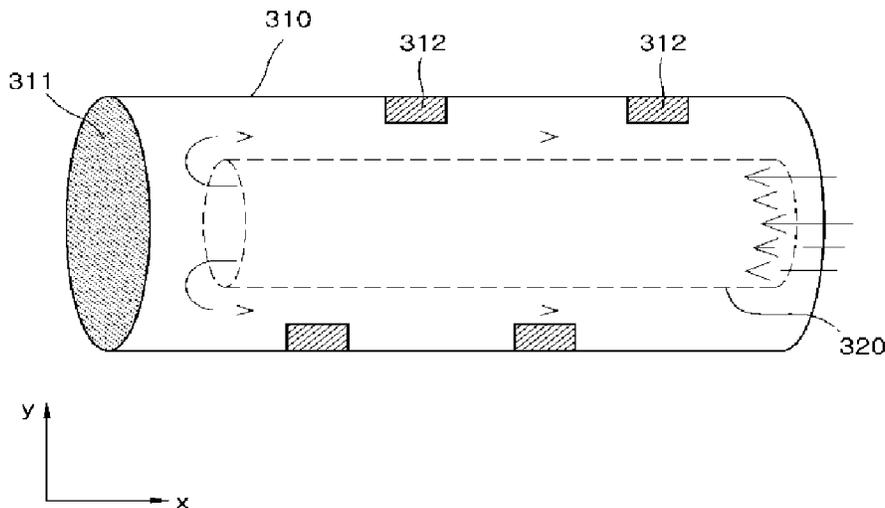
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(57) **ABSTRACT**

A sterilizer may include: a first pipe having an inner wall with a light reflecting property; a second pipe disposed in the first pipe so as to pass fluid therethrough and formed of a light transmitting material; and a plurality of UV LEDs arranged on the inner wall of the first pipe and configured to irradiate sterilization UV light onto the fluid.

**20 Claims, 11 Drawing Sheets**

**300**



**Related U.S. Application Data**

continuation of application No. 16/048,115, filed on Jul. 27, 2018, now Pat. No. 10,525,155, which is a continuation of application No. 15/342,961, filed on Nov. 3, 2016, now Pat. No. 10,046,074, which is a continuation of application No. 14/479,186, filed on Sep. 5, 2014, now Pat. No. 9,533,896.

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FIG. 1A

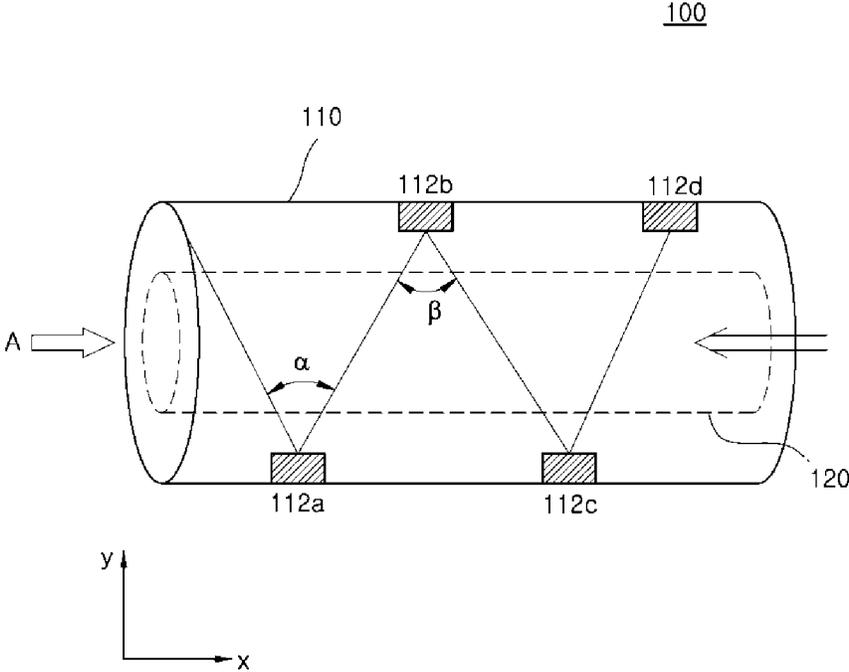


FIG. 1B

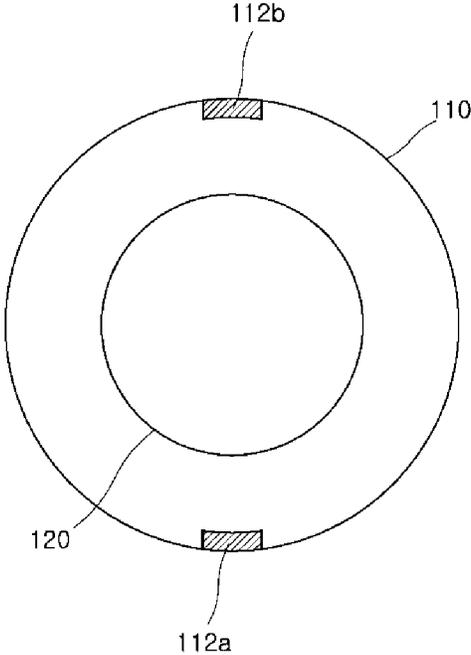


FIG. 2A

200

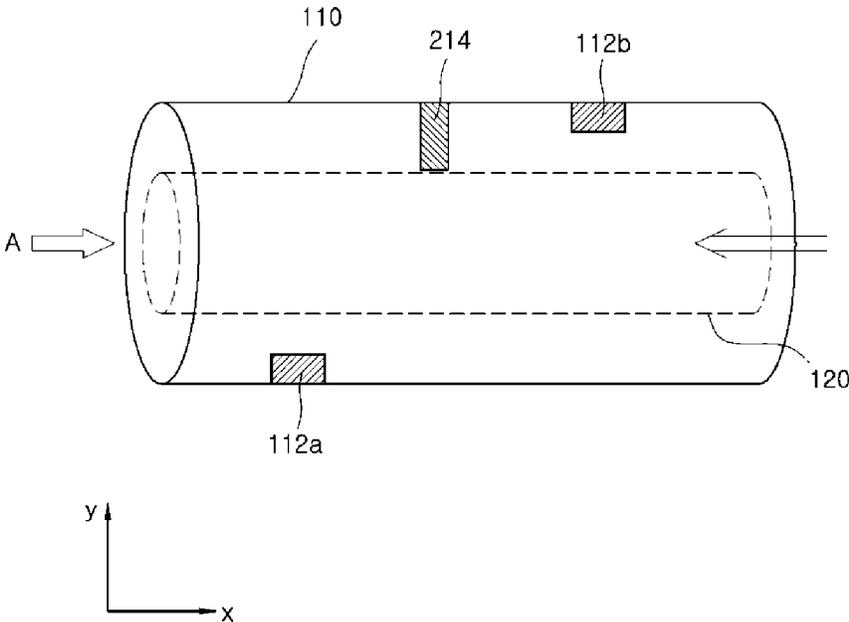


FIG. 2B

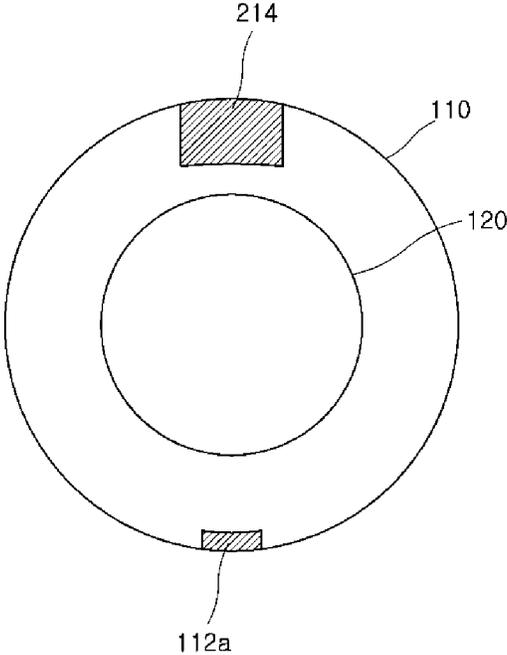


FIG. 3

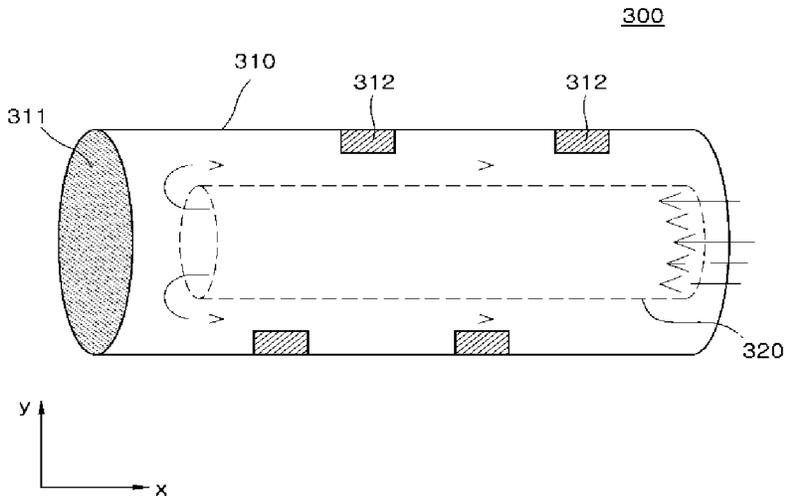


FIG. 4

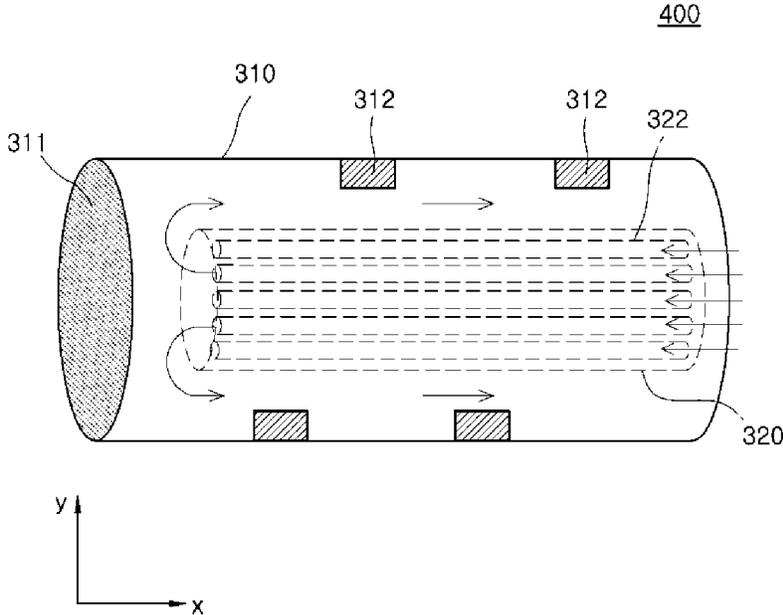


FIG. 5

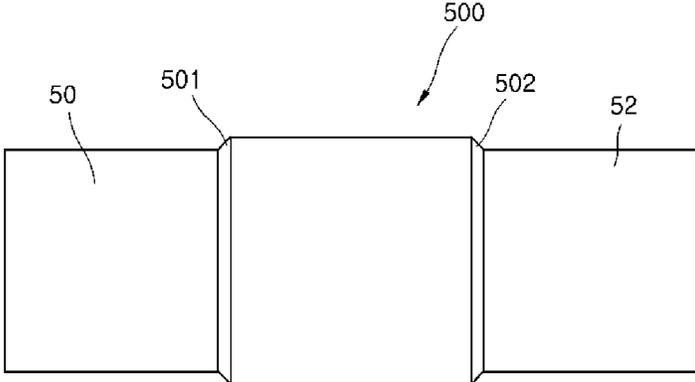


FIG. 6A

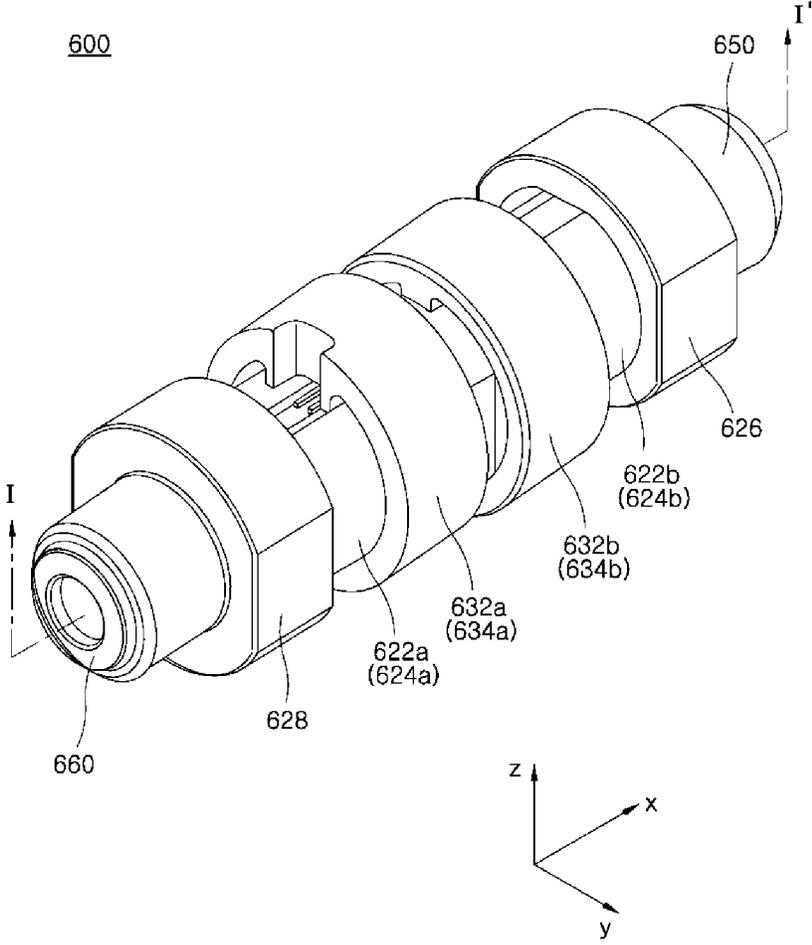
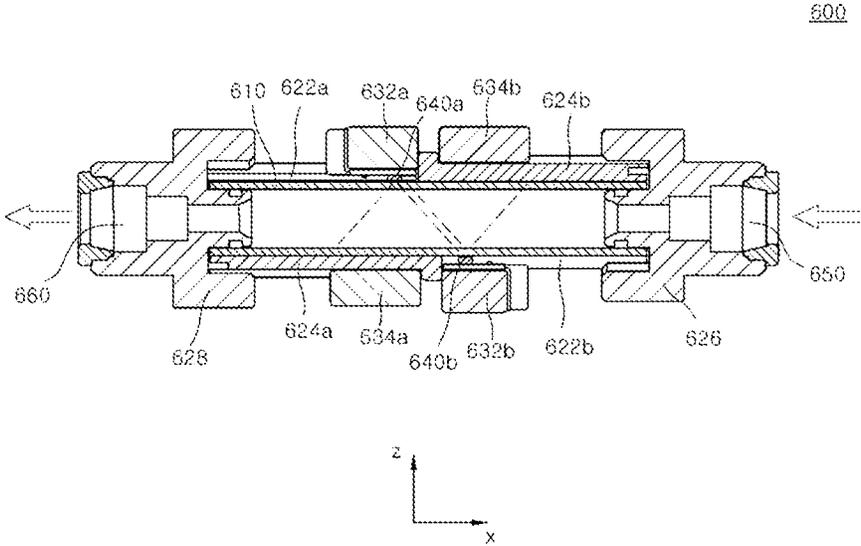


FIG. 6B



600

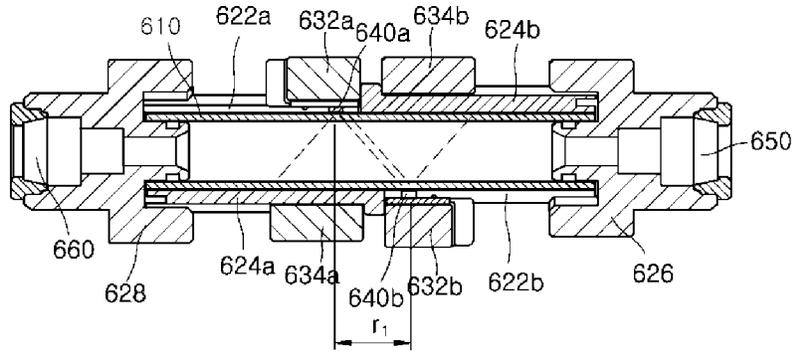


FIG 7A

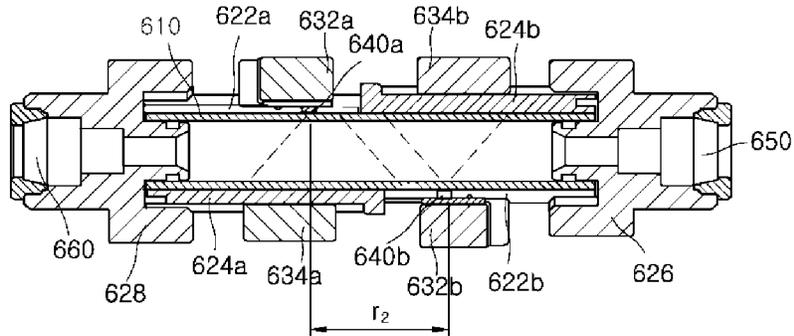


FIG 7B

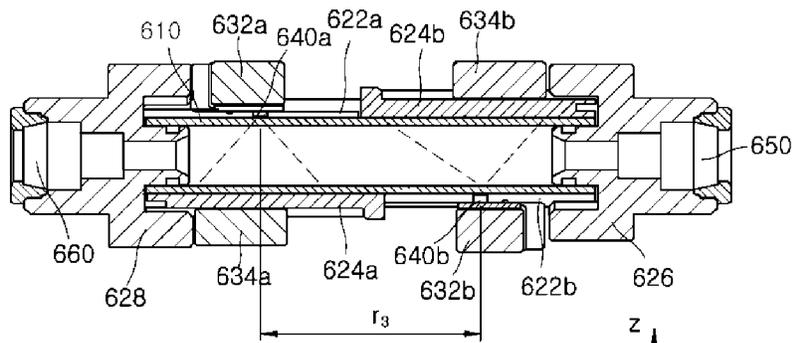


FIG 7C

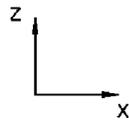


FIG. 8A

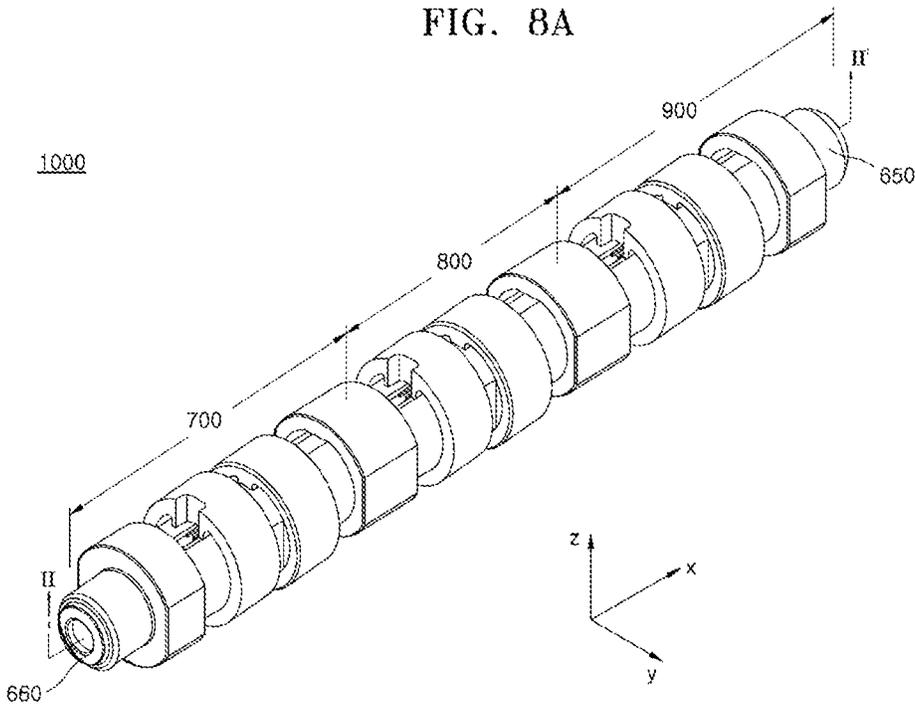
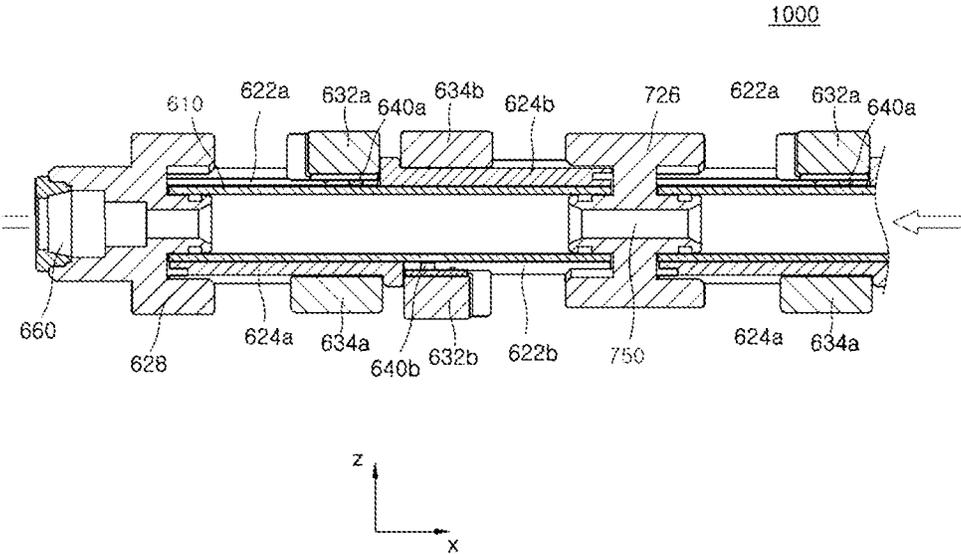


FIG. 8B



## FLUID STERILIZER AND ASSOCIATED CONNECTING DEVICE

### CROSS-REFERENCES TO RELATED APPLICATIONS

This patent document is a continuation of U.S. patent application Ser. No. 16/734,998, filed on Jan. 6, 2020, which is a continuation of U.S. patent application Ser. No. 16/048,115, filed on Jul. 27, 2018, which is a continuation of U.S. patent application Ser. No. 15/342,961, filed on Nov. 3, 2016, which is a continuation of U.S. patent application Ser. No. 14/479,186, filed on Sep. 5, 2014, now U.S. Pat. No. 9,533,896, which claims priorities to, and benefits of, prior Korean application numbers 10-2013-0106872 and 10-2014-0108121 that are filed on Sep. 5, 2013 and Aug. 20, 2014, respectively, and incorporates the above Korean filings by reference in their entirety.

### BACKGROUND

The technology disclosed in this patent document relates to a sterilizer, including a fluid sterilizer and an associated connecting device.

Due to the recent concern about water pollution caused by environmental contamination, the demand for a water purifier has increased. There are various kinds of water purifiers available, such as a natural filtration water purifier, a direct-connection filtration water purifier, an ion-exchange resin water purifier, a distillation water purifier, a reverse osmosis water purifier and others, according to the water purification techniques or processes used for water purification.

Recently, there have emerged water purifiers which directly sterilize water using ultraviolet (UV) light. Many conventional water purifiers using UV light use an underwater UV light source. Such a conventional water purifier, in one example, fills a container with water to be sterilized, and turn on a UV light source dipped or submerged in the water to sterilize the water. The conventional water purifier has advantages in that the installation can be completed by dipping or submerging the UV light source in the container filled with the water, the equipment can be reduced in size, and the installation cost can be saved. However, the conventional water purifier may require a considerable reaction time for irradiating UV light to sterilize water, or may not uniformly sterilize all the water in the container.

One example of such a conventional water purifier using UV light is disclosed in Korean Patent Publication No. 2012-0134809 and entitled "Water purifier".

### SUMMARY

Embodiments of the disclosed technology are directed to a sterilizer capable of shortening a reaction time and improving sterilization uniformity in sterilizing a fluid such as water and a connector using the same.

In one embodiment, a sterilizer for sterilizing a fluid may include: a first pipe having an inner wall that reflects ultraviolet (UV) light; a second pipe disposed in the first pipe to pass a fluid therethrough and formed of a light transmitting material to allow the UV light to enter the second pipe to illuminate and to sterilize the fluid; and a multiple number of UV light emitting diodes (LEDs) arranged on the inner wall of the first pipe and configured to irradiate sterilization UV light onto the fluid.

In another embodiment, a sterilizer for sterilizing a liquid may include: a first pipe having a closed end and an

opposite, open end; a second pipe disposed in the first pipe and having a light transmitting property to transmit ultraviolet (UV) light; and a multiple number of UV light sources engaged to and arranged in the first pipe and configured to provide UV light to a fluid flowing through the inside of the second pipe or the space between the first and second pipes to cause sterilization of the fluid.

In another embodiment, a connector having a function of sterilizing a liquid may include: a first pipe having an inner wall that reflects ultraviolet (UV) light; a multiple number of UV LEDs arranged on the inner wall that produce UV light; a second pipe disposed in the first pipe to pass a fluid therethrough, and structured to transmit the UV light from the UV LEDs into an interior of the second pipe to cause sterilization of the fluid; and connection parts on both ends of the connector to connect two external fluid flow pipes to guide the fluid between the two external fluid flow pipes.

In another embodiment, a sterilizer for sterilizing a fluid may include: a light-transmitting fluid flow pipe having a side wall that transmits ultraviolet (UV) light to a fluid inside the light-transmitting fluid flow pipe to be sterilized; movable units mounted outside of the light-transmitting fluid flow pipe; and UV light sources mounted on the movable units to provide UV light for sterilizing the fluid flowing through the light-transmitting fluid flow pipe. The movable units may adjust the distance between the UV light sources on the body part.

In various implementations of the present disclosure, while a fluid flows through the first or second pipe, the fluid may be sterilized by the UV LEDs. Since the UV LEDs may be reduced in size, they can be easily installed on the inner wall of the first pipe.

Furthermore, by sterilizing a fluid passing through the pipe, the covering area of the UV light may be increased. In addition, the UV light can be provided to the entire fluid by installing a light reflecting structure. Thus, non-irradiation area to which the UV light is not reached does not exist in the fluid.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A schematically illustrates an example of a sterilizer in accordance with a first embodiment of the disclosed technology.

FIG. 1B is a plan view of the sterilizer of FIG. 1A, seen from a direction A.

FIG. 2A schematically illustrates an example of a sterilizer in accordance with a second embodiment of the disclosed technology.

FIG. 2B is a plan view of the sterilizer of FIG. 2A, seen from a direction A.

FIG. 3 schematically illustrates an example of a sterilizer in accordance with a third embodiment of the disclosed technology.

FIG. 4 schematically illustrates an example of a sterilizer in accordance with a fourth embodiment of the disclosed technology.

FIG. 5 schematically illustrates an example of a connector in accordance with the fourth embodiment of the disclosed technology.

FIG. 6A schematically illustrates an example of a sterilizer in accordance with a fifth embodiment of the disclosed technology.

FIG. 6B is a cross-sectional view of the sterilizer of FIG. 6A, taken along line I-I'.

FIGS. 7A to 7C illustrate an example of an arrangement of the UV light sources of the sterilizer in accordance with the disclosed technology.

FIG. 8A is a schematic perspective view of an example of a sterilizer in accordance with a sixth embodiment of the disclosed technology.

FIG. 8B is a cross-sectional view of the sterilizer of FIG. 8A, taken along line II-II.

#### DESCRIPTION OF SPECIFIC EMBODIMENTS

Embodiments of the disclosed technology will hereinafter be described in detail with reference to implementation examples, including those illustrated in the accompanying drawings. It should be noted that the drawings are not to precise scale and may be exaggerated in thickness of lines or sizes of components for descriptive convenience and clarity only.

In describing various embodiments of the present disclosure, when an element is referred to as being positioned on another element or over, under, and at a side of another element, it may indicate the relative positional relationship therebetween. Thus, the former element may be directly contacted with the latter element, or an additional element may be interposed at the interface therebetween. Furthermore, when an element is referred to as being coupled or connected to another element, it may indicate that the former element is directly coupled or connected to the latter element or an additional element is interposed therebetween. Throughout the specification, like reference numerals denote substantially the same components.

In the present specification, the term “pipe” indicates a kind of tube or a pipe-shaped structure, and may include a structure capable of passing fluid through an internal space thereof. The “pipe” may have a cross-section formed in a circular shape or polygonal shape.

Furthermore, “beam angle” may indicate an emission angle at which a light intensity corresponding to 50% or more of the maximum light intensity is obtained, in light emitted from an LED (light emitting diode) chip forming an LED.

A sterilizer in accordance with an embodiment of the disclosed technology includes a first, outer pipe and a second, inner pipe inside the first pipe, forming a dual pipe structure where the inner wall of the first pipe is used to support UV light sources and the second pipe is used to transport the fluid to be sterilized. The sterilizer may have a pipe shape to pass a fluid or a fitting that is shaped to connect a pipe to another pipe.

FIG. 1A schematically illustrates an example of a sterilizer in accordance with a first embodiment of the disclosed technology. FIG. 1B is a plan view of the sterilizer of FIG. 1A, seen from a direction A. Referring to FIGS. 1A and 1B, the sterilizer 100 includes a first pipe 110 as the outer pipe and a second pipe 120 as the inner pipe located inside the first pipe. The inner hollow space inside the second pipe 120 is used to carry and transport a fluid (such as water) to be sterilized under illumination of UV light. The first pipe 110 may include an inner wall having a light reflecting property, thus reflecting light. For example, in one implementation, the inner wall of the first pipe 110 may be coated with a metal having a high reflectance, such as aluminum or silver. In another implementation, the first pipe 110 may be formed of, or may include, a metal having a high reflectance, such as aluminum or silver.

The first pipe 110 may include, or be structured to engage to, UV light sources 112a, 112b, 112c, and 112d which may

be arranged on the inner wall of the first pipe 110. The UV light sources 112a, 112b, 112c, and 112d emit UV light with a wavelength suitable for sterilization, e.g., in a UV spectral range of about 200 nm to 400 nm. More specifically, in some implementations, the UV light sources 112a, 112b, 112c, and 112d may emit UV light with a wavelength of about 200 nm to 290 nm for sterilization. The UV light sources 112a, 112b, 112c, and 112d are arranged to collectively produce the UV light that fills the interior of the second pipe 120 carrying and transporting the fluid to be sterilized and to provide effective illumination for sterilization.

In an embodiment, the UV light sources 112a, 112b, 112c, and 112d may include UV LEDs. The UV LEDs 112a, 112b, 112c, and 112d may be arranged in a zigzag pattern on the inner wall of the first pipe 110 in consideration of the beam angles of UV beams emitted by the UV LEDs in order to provide desired UV illumination coverage within the fluid-carrying second pipe 120 for effective sterilization of the fluid. As shown in FIG. 1B, some of the UV LEDs may be arranged on opposite sides of the second pipe 120 and, as shown in FIG. 1A, the UV LEDs may be spaced from one another along the elongated direction (i.e., X-axis direction as labeled) while still providing sufficient UV illumination inside the second pipe 120 for effective sterilization. Referring to FIG. 1A, for example, the UV LED 112b located on one side of the second pipe 120 may be positioned within the beam angle  $\alpha$  of the light emission or the output UV beam of the UV LED 112a located on the opposite side of the second pipe 120, and, similarly, the UV LED 112c on the same side of the second pipe 120 with the UV LED 112a may be positioned within the beam angle  $\beta$  of the light emission of the output UV beam of the UV LED 112b which is, along with the UV LED 112d, on the opposite side of the second pipe 120. This arrangement of the UV LEDs would ensure the UV light beams emitted by the UV LEDs to have some spatial overlap to fill up the interior space inside the second pipe 120 without leaving any space that is not illuminated by the UV light so that the fluid inside the second pipe 120 is fully illuminated by the UV light for the sterilization operation. In some implementations, for example, the beam angle  $\alpha$  or  $\beta$  may range from about 110° to 140°. FIGS. 1A and 1B illustrate four UV LEDs 112a, 112b, 112c, and 112d, but in other implementations, the number of UV LEDs arranged along the X-axis direction corresponding to the longitudinal direction of the first pipe 110 is not limited to the illustrated example and can vary depending on the longitudinal length along the second pipe 120 for desired sterilization.

Referring to FIGS. 1A and 1B, the UV LEDs 112b and 112d may be arranged on the top inner wall of the first pipe 110 along the X-axis direction or the longitudinal direction of the first pipe 110, and the UV LEDs 112b and 112d may be arranged on the bottom inner wall of the first pipe 110 along the X-axis direction. However, other implementations are also possible. As long as the UV LEDs 112a, 112b, 112c, and 112d are arranged along the X-axis direction to satisfy the above-described condition in which one UV LED is positioned within the beam angle of another UV LED, the UV LEDs 112a, 112b, 112c, and 112d may be arranged in various manners on the inner wall of the first pipe 110.

In the example in FIGS. 1A and 1B, the second pipe 120 is disposed inside the first pipe 110 so as to pass the fluid to be sterilized through the UV illumination section to achieve sterilization. The second pipe 120 may be formed of a light transmitting material which allows the UV light to transmit through the walls of the second pipe 120 to reach the fluid inside the second pipe 120 for the sterilization operation. For

example, the second pipe **120** may be formed of, or include, a quartz pipe. Thus, UV light generated from the UV light sources **112a**, **112b**, **112c**, and **112d** arranged on the inner wall of the first pipe **110** may penetrate the second pipe **120**, and supply the UV light to the fluid. The UV light irradiated into the second pipe **120** can sterilize the fluid.

Although not illustrated, the sterilizer **100** may include a driving device provided at one end or both ends thereof so as to generate a driving force that causes the fluid to follow through the second pipe **120**. The driving device may include, for example, a fluid treatment pump. The driving device may control the flow velocity and rate of the fluid.

As described above, the sterilizer sterilizes the fluid using the UV light sources by making the fluid flow through the UV illuminated section of the second pipe **120**. Since the UV LEDs are used as the UV light sources, the UV light sources may be reduced in size and easily installed on the inner wall of the first pipe **110**. In addition, UV LEDs provide energy efficient UV light production than other UV light sources.

In accordance with the embodiments of the disclosed technology, since the sterilizer sterilizes a fluid by making the fluid pass through the pipe, the sterilizer may be configured to uniformly irradiate UV light on the fluid. Thus, the sterilizer may prevent the occurrence of a non-irradiation area within the fluid, onto which the UV light is not irradiated, while a non-irradiation area occurs in the conventional underwater sterilizers. Furthermore, since the sterilization is performed in a state where fluid is passed through the pipe, the time required for the sterilization may be reduced.

FIG. 2A schematically illustrates an example of a sterilizer in accordance with a second embodiment of the disclosed technology. FIG. 2B is a plan view of the sterilizer of FIG. 2A that is seen from a direction A.

Referring to FIG. 2A, the sterilizer **200** may include some substantially same structure features as the sterilizer **100** described with reference to FIGS. 1A and 1B and the sterilizer **200** further includes a light reflecting structure **214** disposed on the inner wall of the first pipe **110** between the respective UV light sources **112a**, **112b**, **112c**, and **112d**. Thus, the following description will be focused on the structure features in FIGS. 2A and 2B that are different from the sterilizer **100** in FIGS. 1A and 1B in order to avoid duplicate description.

The light reflecting structure **214** may be positioned in the space between the first and second pipes **110** and **120**. For example, the light reflecting structure **214** may be positioned in an area inside the first pipe **110** that is not occupied by the second pipe **120**. The light reflecting structure **214** reflects the UV light generated from the UV light sources **112a**, **112b**, **112c**, and **112d** in cooperation with the UV reflection of the inner wall of the first pipe **110**, thereby expanding the area which is covered by the UV light inside the second pipe **120**. The light reflecting structure **214** can reduce a non-irradiated area of the UV light, which otherwise may occur in the second pipe **120**. FIG. 2A shows one light reflecting structure **214** as an example and multiple light reflecting structures **214** can be implemented. For example, referring back to FIG. 1A, a light reflecting structures **214** can be placed on the top inner wall of the first pipe **110** at a location between LED **112a** on the bottom inner wall of the first pipe **110** and LED **112b** on the top inner wall of the first pipe **110**. This is what is shown in FIGS. 2A and 2B. Additional light reflecting structures **214** can be placed on the top and/or bottom inner wall of the first pipe **110**. As a specific example, an additional light reflecting structure **214** can be placed on the bottom inner wall of the first pipe **110** at a

location between LED **112a** on the bottom inner wall of the first pipe **110** and LED **112b** on the top inner wall of the first pipe **110**, e.g., at a location opposing the light reflecting structures **214** shown in FIG. 2A. Similar additional light reflecting structures **214** can be placed on the bottom/top inner wall of the first pipe **110** at locations between LED **112b** and LED **112c**, between LED **112c** and LED **112d**.

Such light reflecting structures **214** provide light reflecting structures or surfaces beyond the light-reflecting surfaces of the inner walls of the first pipe **110** to reflect the UV light into the interior of the second pipe **120**. The light reflecting structures **214** can be structured and arranged to eliminate a non-irradiation area of the UV light within the second pipe that is not illuminated by the UV light, improve the UV illumination uniformity in the second pipe **120** and increase the overall utilization efficiency of the UV light generated by the LEDs.

Referring to FIG. 2B, the light reflecting structure **214** and the UV LEDs **112b** and **112d** may be arranged in a line on the top inner wall of the first pipe **110** along the X-axis direction, or the light reflecting structure **214** and the UV LEDs **112a** and **112c** may be arranged in a line on the bottom inner wall of the first pipe **110** along the X-axis direction. However, the disclosed technology is not limited to such a configuration. The arrangement of the light reflecting structure **214** on the inner wall of the first pipe **110** may be modified from what is in FIG. 2B in various manners to provide improved UV illumination in the second pipe **120** for sterilization operation.

The above examples in FIGS. 1A, 1B, 2A and 2B can be used to direct a fluid through a sterilization device by inputting the fluid into the device from one end and outputting the sterilized fluid out of the device from the opposite end. In other designs, the fluid may be directed into and out of the device from the same end as shown by an example in FIG. 3.

FIG. 3 schematically illustrates an example of a sterilizer in accordance with a third embodiment of the disclosed technology. Referring to FIG. 3, the sterilizer **300** includes a first, outer pipe **310** and a second, inner pipe **320** disposed inside the first pipe **310**.

In the illustrated example, the first pipe **310** has a closed end **311** at one side of the first pipe **310** and an open end at the other side. Furthermore, the first pipe **310** may include an inner wall having a light reflecting property to reflect the UV light. The closed end **311** may also have a light reflecting property to reflect the UV light. For example, the inner wall and the closed end **311** of the first pipe **310** may be coated with a metal having a high reflectance, such as aluminum or silver.

In the illustrated example, the inner wall of the first pipe **310** includes, or is used to mount or hold, a plurality of UV light sources **312** arranged to provide illumination to the second pipe **120**. In some implementations, UV light sources **312** can be configured and arranged in substantially the same manner as the UV LEDs **112a**, **112b**, **112c**, and **112d** described in FIGS. 1A and 1B.

The second pipe **320** is disposed inside the first pipe **310**, and has a light transmitting property to allow transmission of the UV light through its walls to provide UV illumination of the interior of the second pipe **320**. The second pipe **320** may be formed of, or include, for example, quartz or another suitable optically transmissive or optically transparent material to allow the UV light to enter the interior of the second pipe **320**. As illustrated by the example in FIG. 3, the fluid to be sterilized is guided into and, flows through, the second pipe **320**. The second pipe **320** has two open ends for

conducting the fluid with a first opened end that is used to receive the fluid and is positioned separately from the closed end **311** of the first pipe **310** (facing the open end of the first pipe **310**). The second open end of the second pipe **320** is to direct the received fluid out of the second pipe **310** and is positioned close to the closed end **311** of the first pipe **310**. Due to the above configuration, the flow direction of the fluid flowing through the second pipe **320** is blocked by the closed end **311** of the first pipe **310** and thus is switched in direction or is redirected at the closed end **311** such that the fluid flows along the opposite direction to flow through the space between the first pipe **310** and the second pipe **320**. That is, after the fluid reaches at the closed end **311**, the fluid turns its direction to be opposite and inversely flows in an area inside the first pipe **310** and outside the second pipe **320**. Therefore, the fluid flows through an UV-illuminated section twice in this configuration to receive additional UV exposure that would not be available if the first pipe **310** does not have the closed end **311**. This increased UV exposure can improve the sterilization operation.

Although not illustrated in FIG. 3, a driving device may be provided at the opposite end or side of the closed end **311** to generate a driving force that causes the fluid to flow. For example, the driving device may include a fluid treatment pump or a suitable fluid driving mechanism to direct or force the fluid to flow in the direction as illustrated in FIG. 3. The driving device at the opposite end may generate a driving force to pass the fluid through the second pipe **310**. Alternatively, the driving device may be provided to generate a driving force that causes the fluid to flow in the space between the first and second pipes **310** and **320** along the X-axis. The driving device may adjust the flow velocity and rate of the fluid.

In the example in FIG. 3, the fluid, which is sterilized by the UV light sources **312** while flowing through the second pipe **320**, may be sterilized again by the UV light sources **312** while returning to the opposite end after the flow direction of the fluid is switched at the closed end **311**.

FIG. 4 schematically illustrates another example of a sterilizer in accordance with a fourth embodiment of the disclosed technology. Referring to FIG. 4, the sterilizer **400** may have substantially the same structure in terms of the construction of the first, outer pipe **310** and the second, inner pipe **320** as the sterilizer **300** of FIG. 3 but inside the second pipe **320** in FIG. 4, two or more inner pipes **322** are placed inside the second pipe **320**, which, collectively along with the pipe **320**, operate to guide the fluid for UV sterilization.

The sterilizer **400** may sterilize fluid through the UV light sources **312**, while the fluid flows through inner pipes **322** and the second pipe **320**. Like the second pipe **320**, each inner pipe **322** has a light transmitting property to transmit the UV light from the UV light sources **312** to enter the interior of each inner pipe **322** for sterilizing the fluid inside. For example, the inner pipe **322** may be formed of or include quartz or a suitable UV transparent material. In comparison with the device **300** in FIG. 3, each inner pipe **322** in FIG. 4 can be designed to have a smaller pipe size or inner diameter than that of the second pipe **320**. Accordingly, with other conditions being equal, as the fluid flows through inner pipes **322**, the flow velocity of the fluid inside the second pipe **320** may slow down in comparison with the fluid speed inside the single larger second pipe **320** in FIG. 3, thereby increasing the irradiation time of the UV light per unit volume with respect to the flowing fluid. This increased radiation time can improve the sterilization.

FIG. 5 schematically illustrates an example of a connector in accordance with the fourth embodiment of the disclosed

technology to provide fluid sterilization. Referring to FIG. 5, the connector **500** includes first and second ends or connection ports **501** and **502** coupled to fluid flow pipes **50** and **52**, respectively, to connect the fluid flow pipes **50** and **52** to allow for a fluid to flow through the pipes **520** and **52**. The interfacing with the pipes **50** and **51** at the first and second ends **501** and **502** may be sealed by using a suitable sealing mechanism, including, e.g., publicly-known sealing members, to prevent fluid leak between the fluid flow pipe **50** of the first end **501** and the fluid flow pipe **52** of the second end **502**.

The connector **500** may include substantially the same components as a fluid sterilizer based on the disclosed technology, such as the sterilizer **100** described with reference to FIGS. 1A and 1B or the sterilizer **200** described with reference to FIGS. 2A and 2B. Therefore, the connector **500** can provide fluid sterilization in the fluid that flow between pipes **50** and **51**.

The connector **500** may include the sterilizer mounted in the connection parts of the flow fluid pipes **50** and **52**, and perform UV sterilization on fluid flowing through the fluid flow pipes **50** and **52**.

FIG. 6A schematically illustrates an example of a sterilizer in accordance with a fifth embodiment of the disclosed technology. FIG. 6B is a cross-sectional view of the sterilizer of FIG. 6A, taken along line I-I'.

Referring to FIGS. 6A and 6B, the sterilizer **600** includes a light-transmitting fluid flow pipe **610**, first body parts **622a**, **624a**, **622b**, and **624b** surrounding the light-transmitting fluid flow pipe **610**, and UV light sources **640a** and **640b** for irradiating UV light onto the light-transmitting fluid flow pipe **610** for the sterilization.

The fluid to be sterilized passes through the light-transmitting fluid flow pipe **610** which corresponds to the second pipes **120** and **320** in aforementioned implementations of the present disclosure. Both ends of the light-transmitting fluid flow pipe **610** may be connected to an inlet part **650** for receiving the fluid to be sterilized and an outlet part **660** for exporting the UV-treated and sterilized fluid, respectively.

The first body parts **622a**, **624a**, **622b**, and **624b** may be arranged to surround the outside of the light-transmitting fluid flow pipe **610**. The first body parts **622a**, **624a**, **622b**, and **624b** may be coupled to a second body part **626** for fixing the inlet part **650** and a third body part **628** for fixing the outlet part **660**. In another implementation, the first body parts **622a**, **624a**, **622b**, and **624b** may be integrated with the second body part **626** and the third body part **628**.

The first body parts **622a**, **624a**, **622b**, and **624b** may be arranged along the longitudinal direction of the light-transmitting fluid flow pipe **610**, and may be divided into two or more units. Specifically, for example, FIG. 6A illustrates a first unit **622a** and **624a** and a second unit **622b** and **624b** as separate units. As described below, movable units **632a**, **634a**, **632b**, and **634b** coupled to UV light sources **640a** and **640b** are provided and are disposed at a part **622a** and **622b** of the first and second units **622a**, **624a**, **622b**, and **624b**. Such movable units enable adjustment of positions of the UV light sources in the sterilization operation.

The movable units **632a**, **634a**, **632b**, and **634b** may be coupled to the first body part **622a**, **624a**, **622b**, and **624b**. As illustrated in FIGS. 6A and 6B, the movable units **632a**, **634a**, **632b**, and **634b** may include a ring-shaped structure. The UV light sources **640a** and **640b** may be mounted on at least some of the movable units **632a**, **634a**, **632b**, and **634b**. For example, in FIG. 6B, the UV light sources **640a** and **640b** are provided on the movable units **632a** and **632b**. The movable units **632a**, **634a**, **632b**, and **634b** may be moved

along the longitudinal direction of the first body parts **622a**, **624a**, **622b**, and **624b**. Thus, the positions of the UV light sources **640a** and **640b** coupled to the movable units **632a**, **634a**, **632b**, and **634b** may be changed. In the illustrated implementation, the movable units **632a**, **634a**, **632b**, and **634b** may include a first movable unit **632a** and **634a** and a second movable unit **632b** and **634b**. The first movable unit **632a** and **634a** and the second movable unit **632b** and **634b** may be separately moved on the first body parts **622a**, **624a**, **622b**, and **624b**. As such, the movable units **632a**, **634a**, **632b**, and **634b** may adjust the spatial interval between the UV light sources **640a** and **640b** on the first body parts **622a**, **624a**, **622b**, and **624b**.

The UV light sources **640a** and **640b** may emit UV light with a wavelength of about 200 nm to 400 nm. For example, the UV light sources **640a** and **640b** may emit UV light with a wavelength of about 200 to 290 nm. In one implementation, the UV light sources **640a** and **640b** may include UV LEDs. The UV light sources **640a** and **640b** may be arranged in substantially the same manner as the arrangement of the UV light sources **112a**, **112b**, **112c**, and **112d** in the sterilizer **100** of FIG. 1A. The UV light emitted from the UV light sources **640a** and **640b** may sterilize fluid flowing through the light-transmitting fluid flow pipe **610**.

The inlet part **650** may be disposed in the second body part **626** to transfer fluid from outside into the light-transmitting fluid flow pipe **610**. The inlet part **650** may include a pipe-shaped structure. The fluid flowing through the light-transmitting fluid flow pipe **610** may be sterilized by UV light emitted from the UV light sources **112a**, **112b**, **112c**, and **112d**. The sterilized fluid may be discharged to the outside through the outlet part **660**. The outlet part **660** may be disposed in the third body part **628**, and include a pipe-shaped structure.

FIGS. 7A to 7C illustrate the arrangement of the UV light sources of the sterilizer in accordance with one implementation of the present disclosure. As illustrated in FIGS. 7A to 7C, the positions of the UV light sources **640a** and **640b** may be changed according to the movement of the first movable unit **632a** and **634a** and the second movable unit **632b** and **634b**. Referring to FIG. 7A, the UV light sources **640a** and **640b** may be remote from each other to have a first distance  $r_1$  along a X-axis. As the first movable unit **632a** and **634a** and the second movable unit **632b** and **634b** are moved in the opposite directions away from each other along the X-axis, the distance between the UV light sources **640a** and **640b** may be changed to a second distance  $r_2$  of FIG. 7B or a third distance  $r_3$  of FIG. 7C.

In the case of FIG. 7A, since the distance between the UV light sources **640a** and **640b** is relatively small, UV lights emitted from the UV light sources **640a** and **640b** may overlap each other. Thus, the density of the UV light irradiated onto the fluid may be higher than those in FIGS. 7B and 7C. In the case of FIG. 7C, the sterilization efficiency around the inlet part **650** and the outlet part may become higher as compared to FIGS. 7A and 7B.

FIG. 8A is a schematic perspective view of a sterilizer in accordance with one implementation of the present disclosure. FIG. 8B is a cross-sectional view of the sterilizer of FIG. 8A, which is taken along line II-II'.

The sterilizer **1000** illustrated in FIGS. 8A and 8B includes sterilization modules that are coupled in series. The sterilizer **1000** may include a first sterilization module **700**, a second sterilization module **800**, and a third sterilization module **900**. Each of the sterilization modules **700**, **800**, and **900** may correspond to the sterilizer **600** shown in FIGS. 6A and 6B. To connect sterilization modules to each other, a

connection pipe may be provided between two serially arranged connection modules. For example, between the first and second sterilization modules **700** and **800** and between the second and third sterilization modules **800** and **900**, connection pipes **750** may be disposed to connect second pipes **610** of the sterilization modules **700**, **800**, and **900**, respectively.

The sterilizer **1000** may include an inlet part **650** for introducing fluid and an outlet part **660** for discharging sterilized fluid. FIG. 8B illustrates the detailed structure of the connection part between the first and second sterilization modules **700** and **800**. At the connection part between the first and second sterilization modules **700** and **800**, a second body part **726** may be disposed to fix the light-transmitting fluid flow pipe **610**. An inlet part or outlet part may not be separately provided at the connection part between the first and second sterilization modules **700** and **800**, but other implementations are also possible.

FIG. 8A illustrates that the sterilizer **1000** includes three sterilization modules **700**, **800**, and **900**, but other implementations are also possible on the number of sterilization modules included in the sterilizer **1000**. Each sterilization module may be formed as described with regard to the sterilizer **700** in FIG. 7 and then a plurality of sterilization modules **700** may be connected in series.

Although examples of various embodiments and implementations, including preferred embodiments, of the disclosed technology have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible.

What is claimed is:

1. A sterilizing device for sterilizing a fluid, comprising:
  - a first pipe having a closed end at a first side of the first pipe and having a light reflecting property that reflects ultraviolet (UV) light;
  - a second pipe disposed inside the first pipe and structured to provide a passage for a fluid to pass through the second pipe, the second pipe including a light transmitting material to allow the UV light to enter the second pipe;
  - a light reflector disposed inside the first pipe and arranged to prevent occurrence of a non-irradiation area of the UV light within the second pipe; and
  - a first UV light emitting diode (LED) and a second UV LED that are disposed inside of the first pipe and configured to irradiate the UV light onto the fluid;
    - wherein one of the first UV LED and the second UV LED is positioned within a beam angle of the UV light emitted by the other of the first UV LED and the second UV LED,
    - wherein the second pipe has an open end that is disposed at one side of the second pipe and spaced apart from the closed end of the first pipe, and
    - wherein the closed end of the first pipe is structured to allow the fluid to change a direction of a flow from a first direction to a second direction and cause the fluid to flow along the second direction in a space between the first pipe and the second pipe.
2. The sterilizing device of claim 1, wherein the light reflector is disposed in the space between the first pipe and the second pipe.
3. The sterilizing device of claim 1, wherein the beam angle ranging from 110° to 140°.
4. The sterilizing device of claim 1, wherein the second pipe includes one or more inner pipes placed inside the second pipe.

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5. The sterilizing device of claim 4, wherein each of the one or more inner pipes has a light transmitting property to transmit the UV light to enter an interior of each of the one or more inner pipes.

6. The sterilizing device of claim 4, wherein the one or more inner pipes are structured to provide passages for the fluid to pass through the one or more inner pipes.

7. The sterilizing device of claim 4, wherein the second pipe and the one or more inner pipes include quartz.

8. The sterilizing device of claim 4, wherein irradiation time of the UV light per unit volume for the fluid inside the one or more inner pipes increases as compared to a case when the second pipe has no inner pipes.

9. The sterilizing device of claim 1, wherein the first UV LED and the second UV LED are configured to sterilize the fluid flowing in the space between the first pipe and the second pipe after the fluid changes the direction from the first direction to the second direction at the closed end of the first pipe.

10. The sterilizing device of claim 1, wherein an input for the fluid to enter the sterilizing device and output for the fluid to come out from the sterilizing device are disposed at a second side of the first pipe that is opposite to the first side of the first pipe.

11. The sterilizing device of claim 1, wherein the first pipe includes a metal.

12. A sterilizing device for sterilizing a fluid, comprising: a first pipe having a closed end and an open end that are disposed at opposite sides of the first pipe, the open end of the first pipe configured to allow a fluid to enter the sterilizing device for sterilization;

a second pipe disposed inside the first pipe and having an open end disposed at one side of the second pipe and spaced apart from the closed end of the first pipe; a light reflector disposed inside the first pipe and arranged to prevent occurrence of a non-irradiation area of ultraviolet (UV) light within the second pipe; and

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a first UV light emitting diode (LED) and a second UV LED that are disposed inside of the first pipe and configured to irradiate the UV light onto the fluid;

wherein one of the first UV LED and the second UV LED is positioned within a beam angle of the UV light emitted by the other of the first UV LED and the second UV LED, and

wherein the closed end of the first pipe is structured to allow the fluid to change a direction of a flow from a first direction to a second direction and cause the fluid to flow along the second direction in a space between the first pipe and the second pipe.

13. The sterilizing device of claim 12, wherein the light reflector is disposed in the space between the first pipe and the second pipe.

14. The sterilizing device of claim 12, wherein the beam angle ranging from 110° to 140°.

15. The sterilizing device of claim 12, wherein the second pipe includes one or more inner pipes placed inside the second pipe.

16. The sterilizing device of claim 15, wherein each of the one or more inner pipes has a light transmitting property to transmit the UV light to enter an interior of each of the one or more inner pipes.

17. The sterilizing device of claim 15, wherein the one or more inner pipes are structured to provide passages for the fluid to pass through the one or more inner pipes.

18. The sterilizing device of claim 15, wherein the second pipe and the one or more inner pipes include quartz.

19. The sterilizing device of claim 15, wherein irradiation time of the UV light per unit volume for the fluid inside the one or more inner pipes increases as compared to a case when the second pipe has no inner pipes.

20. The sterilizing device of claim 12, wherein the first pipe includes a metal.

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